Influence of Two-Flap Palatoplasty on Facial Growth in Rabbits

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Three groups of rabbits were used in this study. Group I consisted of control rabbits who had had no surgery. Group II had surgically created but unrepaired clefts of the lip, alveolus, and palate. Group III had surgically created clefts of the lip, alveolus, and palate with the palatal cleft having been repaired using a two-flap palatoplasty. At the end of the twentieth postoperative week, all animals were sacrificed.

Results of the direct cephalometry of the skulls did not confirm the hypothesis that palatal repair inhibits overall facial growth. At the same time, certain asymmetries of the maxilla and mandible were found. These may have resulted from selective inhibition of certain growth processes.

Introduction

The studies of Graber (1949, 1950, 1954); Herfert (1954, 1956, 1958); Kremenak, Huffman, and Olin (1967, 1970); Kremenak and Searls (1971); Meijer and Prahl (1978) and others suggest that various operations on the palate may cause inhibition of facial growth. In contrast, Sarnat (1958) did not find a noticeable inhibition of facial growth in Macaca Rhesus monkeys after elevation and excision of a strip of mucoperiosteum with simultaneous transection of the palatine artery. Sarnat (1971) also noted that the unilateral resection of the hard palate and adjacent sutures did not produce a grossly apparent growth arrest in either the palate or the face. It is evident that the effects of palatal surgery on facial growth are by no means clear.

In 1977, we presented the hypothesis that primary lip repair must also be considered as a possible cause of facial growth inhibition (Bardach and Eisbach, 1977). Studies of rabbits with surgically created clefts of the lip, alveolus, and palate demonstrated that lip repair significantly increased lip pressure on the maxillary complex causing a severe inhibition of anterior posterior facial growth (Eisbach et al., 1978). The correlation found between the amount of lip pressure and the degree of growth inhibition indicated a causal relationship (Bardach et al., 1979). The purpose of the present study is to determine the effects of palatal repair when the cleft of the lip is left unrepaired. The assumption is that palatal repair is also an inhibitor of facial growth, especially transversely.

Results and interpretation of data presented in this paper are not compared to those from other studies since the experimental design used here is original so that results are not directly comparable to those of other authors. In addition, since these data are derived from rabbits, inferences to humans should be made cautiously.

Materials and Methods

Forty-five New Zealand white rabbits, all six weeks old, were used in this study. Rabbits were selected because of their rapid growth and easy management and the availability of large numbers of genetically-controlled strains that assure preoperative intergroup ho-
mogeneity. In addition, since our previous experiments used the same model, intergroup results could be made.

Rabbits from different litters were randomly assigned to one of the following three groups:

Group I 15 rabbits: Unoperated animals

Group II 15 rabbits: Surgically created clefts of the lip, alveolus, and palate left unrepair

Group III 15 rabbits: Surgically created clefts of the lip, alveolus, and palate repaired using the two-flap palatoplasty

To assure preoperative homogeneity of all groups under study, three measures were used: weight, maxillary dimensions, and lip pressure. Maxillary lengths and widths were measured on maxillary casts. Lip pressure was measured with a hydraulic transducer system (Bardach and Eisbach, 1977). Insignificant F-ratios indicated preoperative homogeneity of all three measures.

At the termination of the experiment, body weight and posterior facial widths (bifrontal and bisquamosal dimensions) were used to determine whether changes in facial growth resulted from surgical procedures or from genetic sexual, or feeding variations. Insignificant F-ratios for posterior facial widths and body weight indicated that any subsequent aberrations in the anterior facial skeleton could be attributed to surgical treatment.

General anesthesia was administered to all animals in the study. In rabbits in Groups II and III, clefts of the lip, alveolus, and palate were surgically created. The left half of the upper lip was measured and divided into two equal portions. The medial portion, including the nasal sill, was then excised. The cleft of the alveolus was created between the anterior incisor and the premaxillary-maxillary suture so that both of these landmarks could be preserved. A cleft of the hard palate was made by removal of a strip of tissue five millimeters wide. This included oral mucoperiosteum, part of the horizontal processes of maxillary and palatine bones, and the nasal mucoperiosteum. Bone removal was accomplished with a dental burr (Figures 1 and 2).

The clefts in the animals in Group II were not repaired in order that they might serve as a control group. The palatal clefts in the rabbits in Group III were repaired by means of a two-flap palatoplasty technique. Lateral incisions were carried approximately 0.5 mm lingual to the posterior incisors and medial to the molars. The mucoperiosteal flaps were elevated, and the neurovascular bundles identified. Both flaps were moved medially and sutured together with 4-0 chronic catgut, using horizontal mattress sutures. Additional stitches attached both flaps to the nasal mucoperiosteum. This procedure eliminated dead space under the flaps, thereby improving post-operative healing. Laterally, both mucoperiosteal flaps were reattached to the buccal mucosa, thus eliminating any bare bone (Figure 3). Post-operatively, all animals were given 25 mg of oxytetracycline.

At the end of the twentieth experimental
week, when the rabbits had a life age of 26 weeks, all of the animals were sacrificed. The growth phase of the facial skeleton in rabbits lasts approximately twenty weeks (Engdahl, 1972). Therefore, by sacrificing the rabbits at age 26 weeks, a mature facial skeleton was assured. Removal of soft tissue from the skull was accomplished by larvae of Musca sp. All of the skulls were numbered but were not identified by group in order to avoid bias when measuring.

The following dimensions were measured: maxillary length (Figure 4); maxillary width (Figure 5); maxillary height (Figure 6); posterior facial width (Figure 7); nasal deflection (Figure 7); and mandibular length (Figure 8). The average of two readings of each measurement was used for analysis.

Anterior maxillary width was measured between the premaxillary and maxillary sutures and the nasal septum on each side. This was done because, in most cases, there was a shift of the premaxillary-maxillary suture in the anterior-posterior dimension. Width measurements from suture to suture would, therefore, be oblique and misleading (Figure 5).

Results

Weight. Throughout the 20-week experimental period, Group II rabbits (unrepaired clefts) weighed consistently less than Group I rabbits (unoperated controls), but the differences were not statistically significant. The rabbits in Group III (palatal repair) weighed less than either of the other two groups. The difference in weight between Groups II and

FIGURE 3. Surgically created cleft of the palate is completely closed using two-flap palatoplasty. No bare bone is exposed.

FIGURE 4. Maxillary length measurements:
A-B from the posterior margin of the alveolus of the posterior incisor to the anterior margin of the alveolus of the first molar.
A-C from the posterior margin of the alveolus of the posterior incisor to the masseterica spine of the zygomatic process. A-C seems to be shorter than A-B. However, this false impression is caused by this particular view (profile). The true relationship of A-B and A-C is presented in Figure 5.
A-E from the posterior margin of the alveolus of the posterior incisor to the pterygoid hamulus.
FIGURE 5. Maxillary width measurements:
L-J: from medial margin of the premaxillary-maxillary suture on the cleft side to the midline of the nasal septum.
K-J: from the medial margin of the premaxillary-maxillary suture on the non-cleft side to the midline of the nasal septum. Attention should be paid to the different levels of the premaxillary-maxillary sutures.
M-N: between medial margins of the alveoli of the first molars.
O-P: between medial margins of the alveoli of the last molars.
A-B: See Figure 4.
A-C: See Figure 4.

III was significant for weeks two, four, and 12 of the experiment.

Maxillary Length. Three maxillary length measurements on the right and left sides for each of the three groups and their standard deviations are presented in Table 1.

There are no significant differences between sides for animals in the unoperated group. In the unoperated cleft control group, the left side (cleft side) is consistently longer than the right side, but none of the differences significant. Two of the three comparisons of length in the group having palate repair were significantly different (left side longer).

Table 2 presents the results of analysis of variance on maxillary lengths for each measurement and for each side. It shows that there are significant differences among groups for all measurements except A-C on the left side. Table 2 also presents results of Tukey’s test which show significant pairwise differences. In all length parameters, except A-C on the left side, the unoperated control group was significantly shorter than the unoperated group. The differences found between the unoperated control group and the palate repair group were significant in two of six length measurements. There were no significant differences found between the groups with unoperated and repaired clefts.

Maxillary Width. Table 3 presents descriptive statistics of the width variables. An analysis of variance was performed on each of these variables (Table 4). All intergroup differences were significant for the K-J measurement (premaxillary-maxillary suture to the septum on the right side). This distance was the largest in unoperated controls, and the smallest in the group with unrepaired clefts. There were no significant intergroup differences found for the corresponding variable on the left side (L-J). Analysis of variance showed significant intergroup differences for the distance between the first molars (M-N) and the distance between the last molars (O-P). Tukey’s test indicated that this finding was the result of differences between the unoperated and the unrepaired cleft groups and between the unoperated group and the group having palatal repair. A comparison of the K-J and L-J measurements was performed within each group. This analysis of symmetry revealed that the L-J distance was significantly greater than the K-J distance in both the unoperated and cleft repaired groups than it was in the unoperated group.

Posterior Facial Width. Measurements were taken in two dimensions. Analysis of variance indicated that there were no signifi-
Maxillary Height. Two measurements of maxillary height were taken on each side of the skull. Analysis of variance indicated that there were no significant differences among the groups under study.

Nasal Deflection. Analysis of variance indicated that there were significant intergroup differences. The significant results were between the unoperated and the unrepaired cleft groups and between the unoperated group and the group with repaired clefts. In both groups with surgically-created clefts, nasal deflection was significantly greater than in the unoperated group. No significant difference was found between groups with unrepaired and repaired clefts.

Mandibular Length. Three measurements of mandibular length were taken on each side. No significant intergroup differences were found. When the right and left measurements were compared within each group, a significant asymmetry of mandibular length was observed.

Posterior Facial Width Measurements:
Y-Y': between lateral margins of the frontal bone in front of its posterior supraborbital process.
Z-Z': between the most posterior point of the suture between the zygomatic process of the squamosal and the zygomatic bone on each side of the skull. Nasal deflection: A straight line along the suture between the right and left frontal bones was extended forward towards the tip of the snout. The angle formed by this line and the nasal suture line at the tip of the snout was measured on photographs.
FIGURE 8. Mandibular length measurements:
S-T: from the anterior margin of the mandible to the anterior margin of the alveolus of the first molar.
S-U: from the anterior margin of the mandible to the posterior margin of the alveolus of the last molar.
S-V: from the anterior margin of the mandible to the posterior margin of the body of the mandible.

TABLE 1. Means, Standard Deviations and Sample Sizes of Maxillary Length

<table>
<thead>
<tr>
<th>Length Measurement</th>
<th>I Unoperated Control</th>
<th>II Unrepaired Cleft Control</th>
<th>III Palate Repair</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean (mm)</td>
<td>SD</td>
</tr>
<tr>
<td>A-B Right</td>
<td>15</td>
<td>29.28</td>
<td>1.22</td>
</tr>
<tr>
<td>A-B Left</td>
<td>15</td>
<td>29.25</td>
<td>1.17</td>
</tr>
<tr>
<td>A-C Right</td>
<td>15</td>
<td>34.22</td>
<td>1.35</td>
</tr>
<tr>
<td>A-C Left</td>
<td>15</td>
<td>34.15</td>
<td>1.38</td>
</tr>
<tr>
<td>A-E Right</td>
<td>15</td>
<td>57.20</td>
<td>2.17</td>
</tr>
<tr>
<td>A-E Left</td>
<td>15</td>
<td>57.10</td>
<td>2.20</td>
</tr>
</tbody>
</table>

found in the group that had had palatal repair. For this group, two of the three lengths were significantly greater on the right (non-cleft) side.

Occlusion. It was noted that, in rabbits from Groups II and III, the earliest evidence of changes in the occlusion, in the form of anterior crossbite, became evident two to three weeks after surgery. In some cases, the malocclusion was very severe (Figure 9). Details of these changes in occlusion will be presented in a separate publication.

Discussion

In humans, lip repair ordinarily precedes palatal repair by a year or more. This means that the cause of facial growth inhibition is limited to the lip repair for this time interval. The finding in this study of inhibitory effects on facial growth indicate that both lip and
TABLE 2. Analysis of Variance Results for Maxillary Lengths

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>Control vs. Unrepaired Cleft</th>
<th>Control vs. Palate repair</th>
<th>Unrepaired Cleft vs. Palate repair</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-B Right</td>
<td>Between Groups</td>
<td>2</td>
<td>8.46***</td>
<td>significant</td>
<td></td>
<td>significant</td>
</tr>
<tr>
<td>A-B Left</td>
<td>Within Groups</td>
<td>42</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A-C Right</td>
<td>Between Groups</td>
<td>2</td>
<td>4.63*</td>
<td>significant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A-C Left</td>
<td>Within Groups</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A-E Right</td>
<td>Between Groups</td>
<td>2</td>
<td>7.54**</td>
<td>significant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A-E Left</td>
<td>Within Groups</td>
<td>42</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Tukey's test**

* indicates significance at α = .05
** indicates significance at α = .01
*** indicates significance at α = .001
TABLE 3. Means and Standard Deviations for Maxillary Width

<table>
<thead>
<tr>
<th>Width Measurement</th>
<th>Unoperated Control</th>
<th>Unrepaired Cleft Control</th>
<th>Palate Repair</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean (mm)</td>
<td>SD</td>
</tr>
<tr>
<td>K-J</td>
<td>15</td>
<td>3.47</td>
<td>0.13</td>
</tr>
<tr>
<td>L-J</td>
<td>15</td>
<td>3.45</td>
<td>0.14</td>
</tr>
<tr>
<td>M-N</td>
<td>15</td>
<td>12.13</td>
<td>0.82</td>
</tr>
<tr>
<td>O-P</td>
<td>15</td>
<td>14.20</td>
<td>0.75</td>
</tr>
</tbody>
</table>

TABLE 4. Analysis of Variance Results for Maxillary Widths

<table>
<thead>
<tr>
<th>Measurement</th>
<th>df</th>
<th>Control vs. Unrepaired Cleft</th>
<th>Control vs. Palate Repair</th>
<th>Unrepaired Cleft vs. Palate Repair</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-J</td>
<td>2</td>
<td>15.03*** (H-value) significant</td>
<td>significant</td>
<td>significant</td>
</tr>
<tr>
<td>L-J</td>
<td>2</td>
<td>1.58 (H-value)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M-N</td>
<td>2,42</td>
<td>6.42** (F-value) significant</td>
<td></td>
<td>significant</td>
</tr>
<tr>
<td>O-P</td>
<td>2,42</td>
<td>5.24** (F-value)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Kruskal-Wallis Test used because of nonhomogeneity of variances.
** indicates significance at α = .01
*** indicates significance at α = .001

clefts (Group II). It was assumed that these groups would make it possible to measure the effects of both the surgical creation of the cleft and the subsequent palatal repair. As far as we know, this design has not been used in previous investigations studying the effects of palatal surgery on mid-facial growth. By repairing the cleft palate and leaving the cleft lip unrepaired, we eliminated the influence of lip repair on mid-facial growth.

The data from the present study indicate that there are significant differences in five of six measurements of length between the unoperated and the unrepaired cleft groups. This confirms our previous findings (Eisbach et al., 1978) that surgical creation of unilateral cleft lip, alveolus, and palate results in inhibition of anterior-posterior maxillary growth. In only two of six measurements of length were significant differences found between the unoperated control group and the group having palatal repair. However, no significant differences were found between the two groups with surgically-created clefts. This seems to indicate that cleft palate repair does not contribute to overall growth inhibition and that, together, they result in secondary maxillofacial deformities.

This study employed two control groups, one consisting of unoperated rabbits (Group I) and the other of those with unrepaired palatal surgery contribute to overall growth inhibition and that, together, they result in secondary maxillofacial deformities.
not add to (or counteract) the inhibition of anterior-posterior maxillary growth caused by surgical creation of the cleft.

In the group with repaired clefts of the palate, measurements were significantly larger on the cleft side than on the non-cleft side in two out of three measurements. This difference in length can be explained by the rotation of the snout resulting from muscle imbalance, with more muscles acting on the non-cleft side. Similar findings were reported by Verwoerd-Verhoeff (1974) and Verwoerd et al. (1976).

Measurements of maxillary width revealed that, in all instances except one, both groups with surgically-created clefts had narrower maxillae than the unoperated controls. The maxillary width in the repaired group was smaller than in the unrepaired group, but the differences were not significant.

One unexpected finding was the result of comparisons of the L-J measurement (see Figure 5) where the repaired group was significantly wider than the unoperated control group. This finding can be explained by changes in the position of the premaxillary-maxillary suture and the nasal septum as they relate to each other. The premaxilla was rotated because of the surgically-created cleft, and the septum is deviated along the entire premaxilla (Figure 10).

The hypothesis tested by this investigation was that repair of a cleft palate is an inhibitor of facial growth. The results did not confirm this hypothesis. While palatal repair appeared to cause a constriction of maxillary width, the difference among groups failed to reach significance. Perhaps the size of the sample was too small.

An analysis of symmetry of facial growth was also performed by comparing corresponding right and left measurements within each group. In the group having palatal repair, five out of ten measurements yielded significant differences between sides. These differences were found in maxillary length, mandibular length, and maxillary width. The left side (cleft side) was found to be larger in maxillary length and width and smaller in mandibular length, yielding an asymmetrical facial skeleton. In the unrepaired cleft control group, only the differences in maxillary width were significant. There was no facial asymmetry found in the unoperated control group.
These findings indicate that palatal repair may cause more growth aberrations than surgical creation of the cleft alone.

**Summary**

The results of this study do not confirm the hypothesis that palatal repair inhibits overall facial growth. However, palatal repair was shown to cause asymmetrical maxillary and mandibular growth, and there were indications that palatal repair may affect growth differentially by inhibiting some processes and not others. Further research is necessary to discover the full effects of palatal surgery on facial growth.

**References**


